



Testing and Substituting Transistors

No doubt like me, you have been called upon to try and sort out some piece of equipment and find the only piece of technical information you can get your hands on is a circuit diagram. You can soon check that there is voltage on the HT line but what voltage should there be on the various transistors?

When trying to understand the operation of a stage in transistorised equipment, it is worth trying to check if the voltages make sense.

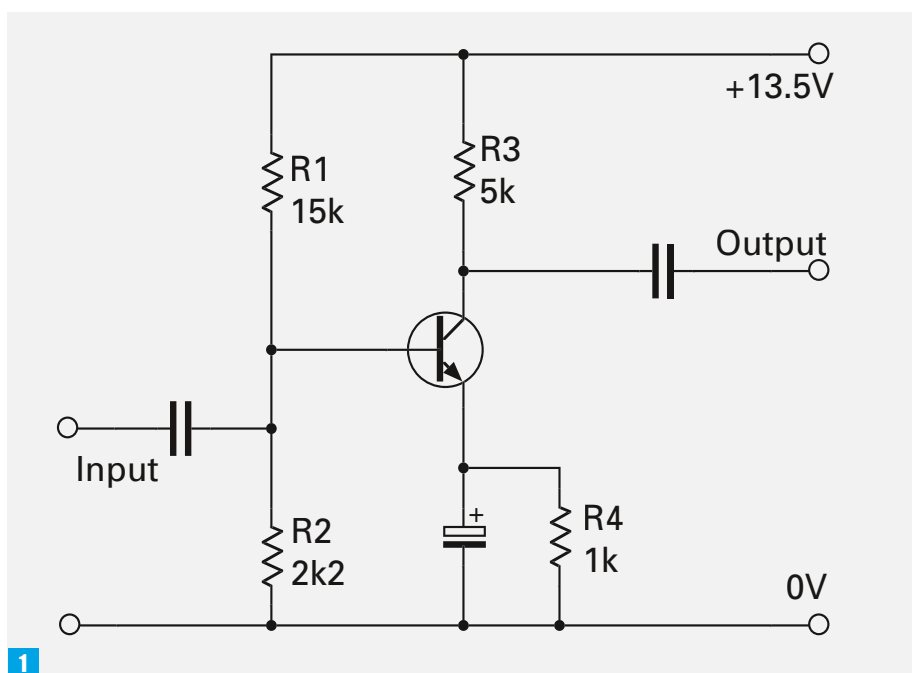
Look at the simple audio amplifying stage shown in Fig. 1, which uses a BC108 NPN silicon transistor, and try to estimate approximately what voltage should be on the base of the transistor. First, note that the voltage on the base of the transistor is provided by the potential divider R1 and R2; but how much is this reduced by the load of the transistor?

The DC input impedance of the base of a transistor is approximately equivalent to the value of the emitter resistor R4, multiplied by the gain of the transistor. The gain of a small audio amplifying transistor such as the BC108 that is functioning correctly can be expected to be between 100-400, so the DC input impedance of the transistor will be in the region of 100 to 400k Ω . As this is much higher than R2, it will have negligible effect on the base voltage, which will be determined by the ratio of R1 and R2. As R2 is around seven times smaller than R1 we can then expect there to be about 1.6V at the junction of R1 and R2 if this is measured by a high impedance voltmeter.

If we note this voltage, the next question is how much voltage there should be on the emitter at its junction with R4? A correctly operating silicon transistor should have between 0.5 and 0.7 times the voltage on its emitter compared with that on its base. If the supply voltage and the transistor are fine, then the emitter voltage should be somewhere in the region of 1V.

From Ohms law, if 1V is measured

Harry Leeming G3LLL steers readers through the labyrinth of transistor types and designations, offering advice on suitable substitutions.



across R4, then 1mA must be flowing through it, and likewise through R3. 1mA flowing through R3 will drop 5V, hence there should be around 8V on the collector.

With a few very simple rough calculations like this, it is possible to ascertain whether or not the DC voltages in various stages of the equipment that you are repairing or constructing are as you would expect, so saving yourself a lot of time.

Why so many Transistor Types?

A friend of one of my engineers, who worked for a large manufacturer, sometimes dropped in for a chat. We put to him the question as to why there are so many different transistor types. He explained that when they ran a production line for one type of valve, say an EL84, all that came off the line were EL84s. They

were then tested, and any that did not meet the EL84 specification were scrapped. With transistors the system was entirely different.

A production line for low power audio transistors, for instance, would produce many 'different' transistors in the same batch due to production spreads. They then had to be sorted out into types when they were tested.

At that time we required 600 transistors with a gain of over 400 as per a BC109C, but with a voltage rating of over 40 (similar to a BC107). He explained that the BC107, BC108, and BC109 were the same transistor. It's just that they were stamped after they had been checked, and that they could be further sub-divided for gain. Hence, they could come out of the factory as nine different types of transistor. He said, "Order 1001 BC109C transistors, the

highest gain type, because with the bulk price this will cost little more than ordering 600, and then test them". He assured us that 95% would have a voltage rating of over 40.

He explained that the maximum voltage that can be applied to a transistor can be tested without doing any damage, and this is what manufacturers do on the production line. If they have large order for a batch of 50W 40V transistors, for example, they will test them to ensure that a batch of their 50W transistors comply. It may be that some of them will stand 60V but if they don't have a requirement for 60V transistors at the time, they will give them a 40V rating and stamp them with a type number accordingly.

A Suitable Tester

The tester we knocked together acting on his advice is shown in **Fig. 2**. This checked the voltage at which the junction between the base and the collector started to pass reverse current. The 150V test meter, comprising the 1.5M Ω resistor and the 100 μ A meter movement, indicated the voltage then present, and hence the transistor's 'real world' breakdown point. The 100k Ω resistor, as well as providing the collector load, limited the current so that the transistor would not be damaged.

Sure enough, when we tested our batch of BC109 transistors, most could take the higher voltage. To be on the safe side we only fitted the ones that tested out at well over 40V, and never had a single device fail in the camera shutter speed testers we were making.

For general work I couldn't afford to have thousands of different kinds of transistors in my service department stock so having this inside knowledge was of great advantage when servicing equipment. If, for instance, I needed a series pass transistor in a 50V power supply, I may find that I only had a few of the correct wattage rating that were rated at a maximum collector-to-emitter voltage of 40V. In that case I found that by testing a few rated at 40V, I would almost always discover several that checked out at well over 50V, and hence were quite safe to use.

Transistor Equivalents

Goodness knows how many times I was asked in the shop whether I had an equivalent for a transistor, mainly by the older generation who, like me, were more familiar with valve technology.

In the 1970s when I was repairing Hi-Fi

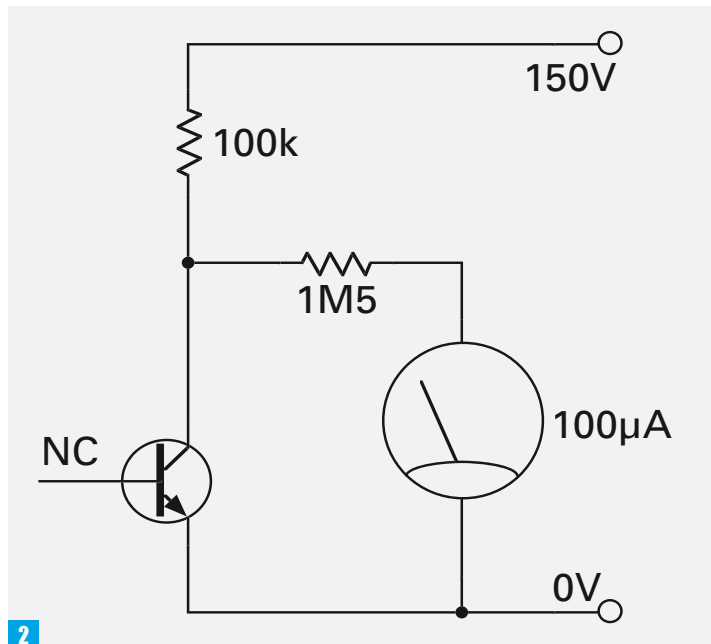


Fig. 1: Simple audio amplifier stage, based around a BC108. Fig. 2: tester to check transistor breakdown voltage.

equipment, if I needed, say, a 6L6 valve, I consulted my 'equivalent' booklet and found that a KT66 or an EL37, which I possibly had in stock, was a direct plug-in replacement. I was then able to proceed and see whether the equipment worked correctly (Although if these were in a push-pull output stage, I would fit a matched pair before returning the equipment to the customer).

There are equivalent lists of transistors but it's quite possible that you will not be able to find any reference to the device in question. In these cases, quite often you will be able to 'get away' with substituting a device that serves the same function in another piece of gear. If, for instance, you need an RF stage Dual-Gate FET for a Yaesu HF rig, the odds are that a Dual-Gate FET that is the same size, looks the same, and does the same job in a Trio HF rig will be perfectly satisfactory.

Running a Shop

Last time I was talking about some of the problems of running a business, and high up on this list is security. It was a sore point that with the cost of alarms, window shutters, insurance and so on, we were forced to spend more keeping unwanted customers out than we spent on advertising trying to entice the ones we wanted in.

Very soon after opening the shop I noted that we were visited by several doubtful looking types, who obviously came in to have a good look round. Commercial CCTV equipment was then a lot more expensive than it is now but a friend **Eon** who ran

a video recorder and TV repair business, came up with a cheap solution. He provided an old video recorder on which the tuner and the timer were faulty, and a CCTV camera and monitor that he had picked up at a rally. The video equipment was wired to a push-button behind the till, the video recorder being hidden. The monitor was on a shelf facing the shop door and one of the first things customers saw when entering the shop was their own face. While this may have been a plus point with some ladies, who immediately started to straighten their hair, it was a real 'turn off' to anyone thinking of robbing us, and visits of people who were obviously 'casing the joint' fell off dramatically.

And Finally, More Time for Your Hobby?

Like many readers, no doubt, I try to do my fair share of the household chores and I normally clean the bathroom. For years I had struggled trying to remove sticky deposits of soap, together with the mould which tended to grow on it, when I saw a comment in a letter in a newspaper, "*In nearly all cases you can guarantee that anyone who generously lathers themselves with a bar of soap, is not the person who has to clean the bathroom*".

I somehow had been brainwashed into thinking that liquid soap was only for the ladies but I followed the advice and we swapped over to shower and hand gel. What a difference! The sink bath and shower now look brighter and cleaner before I give them their weekly clean, than they did previously after my labours. You live and learn. 73 for now, Harry.